INVESTIGATION 6-A

Superball™ Boost

TARGET SKILLS
- Predicting
- Performing and recording
- Analyzing and interpreting

In the discussion in the text, it was predicted that if a tiny Superball™ is held above a far more massive ball and the two are dropped at the same time, the Superball™ should triple its speed. This assumes that the collision is completely elastic and that the large ball does not significantly slow down during the collision. In this investigation, you will determine how valid those assumptions are.

Problem

How does the speed with which a Superball™ leaves a collision with a more massive ball compare with the theoretical speed?

Equipment

- Superball™
- more massive ball, such as a lacrosse ball
- metric measuring tape

CAUTION Wear a face shield if you are conducting this experiment. The other students must wear safety goggles.

Procedure

1. Hold the Superball™ just above the larger ball and at a height of 0.50 m from the floor.
2. Drop the two together so that the Superball™ will land on top of the larger ball.
3. If the Superball™ bounces straight upward, observe how close the ball comes to the ceiling.
4. Adjust the drop height until the upward-bouncing Superball™ just touches the ceiling.
5. Measure and record the drop height, the diameter of the lacrosse ball, and the height of the ceiling.

Analyze and Conclude

1. Determine the actual drop distance for the Superball™ by subtracting the diameter of the lacrosse ball from the initial height of the Superball™ above the floor. (This assumes that the lacrosse ball has not risen significantly before colliding with the Superball™.)
2. Calculate the speed of the Superball™ just before it collided with the lacrosse ball.
3. Determine the actual height through which the Superball™ rose to reach the ceiling.
4. From the maximum height that the Superball™ attained, determine its actual speed just after the collision with the lacrosse ball.
5. What was the theoretical speed of the Superball™ after the collision?
6. How well does the measured speed compare with the theoretical speed? Express your answer as a percentage.
7. Discuss possible reasons for the difference between the actual speed and the theoretical speed.
8. A comparison of the actual height of the bounce to the theoretical height gives a direct comparison between the amount of kinetic energy the ball received and the theoretical amount of kinetic energy. Express the actual kinetic energy as a percentage of the theoretical kinetic energy. How efficient was this process in transferring energy to the Superball™?

Apply and Extend

9. Provide several suggestions for improving the precision of this investigation.

6.3 Section Review

1. K/U Describe how Newton's third law of motion relates to propulsion in space.

2. K/U Show why the mass rate of flow and exhaust velocity are both involved in the development of thrust.

3. K/U
   (a) During the slingshot procedure for increasing the speed of a space probe, what happens to the orbital speed of the planet? Give reasons for your answer.
   (b) Should you be concerned about this? Justify your answer.

4. MC Which planet is most likely to provide the best "slingshot" effect, Jupiter or Mercury? Give reasons for your choice.

5. C Two identical rocks with equal masses and equal speeds collide head-on in space and stick together.
   (a) Explain why there will be no motion of the clump after the collision.
   (b) If all of the initial kinetic energy is changed into thermal energy in the collision, which situation will create the greater amount of thermal energy?
      - doubling the masses of the rocks, but leaving the speeds the same
      - doubling the speeds of the rocks, while leaving the masses the same

      Give reasons for your choice.
   (c) Is it possible that one of those two situations will result in no change in the temperature increase during the collision? Justify your answer.

6. I By means of a series of diagrams, predict the speed at which a Superball™ would bounce if it was falling on top of a much more massive ball, which was in turn falling on top of an extremely massive ball.

7. MC One method of propulsion that does not involve the ejection of reaction mass is the use of a "solar sail." This device consists essentially of a thin film that could cover an area equal to the size of several football fields. It would be stored during lift-off and unfurled out in space. Light from the Sun (or from huge lasers on Earth) would exert pressure on the sail. At the distance that Earth is from the Sun, the pressure of sunlight would be about 3.5 N/km^2. How realistic is this concept for space travel? What are its advantages and disadvantages?